FINAL REPORT

19960303

QUALITY EVALUATION AND RESEARCH IN SUPPORT OF SPICE AND PULSE CROP BREEDING PROJECTS

May 2002
Funded by the Agri-Food Innovation Fund

Prepared by: University of Saskatchewan

AGRI-FOOD INNOVATION FUND

Canada

Saskatchewan

Quality Evaluation and Research in Support of Spice and Pulse Crop Breeding Projects

AFIF Project 96000303

Final Report

1 April 1997 to 31 March 2002

J.Y. Han[1], R.T. Tyler[1], G.C. Arganosa[2] and G.G. Rowland[2]
[1]Department of Applied Microbiology and Food Science
[2]Crop Development Centre
University of Saskatchewan, 51 Campus Drive
Saskatoon, Saskatchewan S7N 5A8

Research Support Provided by the

Canada-Saskatchewan Agri-Food Innovation Agreement
Agri-Food Innovation Fund

In conjunction with the

Saskatchewan Pulse Growers Association
and the
Saskatchewan Herb and Spice Association

Table of Contents

Section		Page
1.	**Introduction**	1
2.	**Assessment of Methods for the Canning Quality of Dry Bean (*Phaseolus vulgaris* L.)**	3
	2.1 Development of New Canning Protocols Using Smaller Cans	5
	2.1.1 Results and Discussion	6
	2.2 Development of Alternative (Non-canning) Quality Evaluation Methods	16
	2.2.1 Results and Discussion	16
	2.3 Development of a Method for Assessing Canning Quality Using Near Infrared Reflectance Spectroscopy (NIRS)	18
	2.3.1 Results and Discussion	18
	2.4 Recommendations	23
	2.5 References	24
3.	**Canning Quality of Pulses**	26
	3.1 Canning Quality of Dry Beans	27
	3.1.1 Canning Quality of Black Bean	27
	3.1.2 Canning Quality of Great Northern Bean	28
	3.1.3 Canning Quality of Navy Bean	30
	3.1.4 Canning Quality of Pink Bean	32
	3.1.5 Canning Quality of Pinto Bean	34
	3.1.6 Canning Quality of Red Bean	36
	3.1.7 Canning Quality of Minor Market Classes of Dry Bean	38
	3.2 Canning Quality of Field Pea, Chickpea and Lentil	39
	3.2.1 Canning Quality of Field Pea	39
	3.2.2 Canning Quality of Chickpea	40
	3.2.3 Canning Quality of Lentil	40
	3.3 Conclusions	41
4.	**Development of Bleaching Evaluation Techniques for Red and Green Cotyledon Pulse Cultivars**	50
	4.1 Conclusions	52
5.	**Development of Nutritional Profiles for Pulse Crops**	54
	5.1 Determination of Folate Concentrations in Starchy Grain Legumes	55

5.1.1 Results and Discussion 57
5.1.2 Recommendations 58
5.2 References 59
6. Spice Quality Evaluation 64

GENERAL SUMMARY AND CONCLUSIONS 67
DISSEMINATION AND USE OF RESULTS 70
REPORTS, PUBLICATIONS AND PRESENTATIONS 72
ACKNOWLEDGEMENTS 75
STATEMENT OF EXPENDITURES 75
PERSONNEL 75

LIST OF FIGURES

Figure **Page**

2.1 Texture of Great Northern bean (cv. Crocus) canned in 4 fl oz can under various conditions 14

2.2 Texture of navy bean (cv. Laser) canned in 7 and 10 fl oz cans under various conditions 15

LIST OF TABLES

Table **Page**

2.1 Modified canning protocol used in this study 10

2.2 Quality traits of canned beans using the standard processing protocol 11

2.3 Proposed retort times (min) for various sizes of cans at a retort temperature of 115.6°C 12

2.4 Proposed retort times (min) for various sizes of cans at retort temperature of 121°C 13

2.5 Statistical correlations between quality traits of navy bean and NIR spectra 21

2.6 Statistical correlations between quality traits of black bean and NIR spectra . . . 21

2.7 Statistical correlations between quality traits of pinto bean and NIR spectra . . . 21

2.8 Statistical correlations between quality traits of red bean and NIR spectra 22

2.9 Statistical correlations between quality traits of pink bean and NIR spectra 22

2.10 Statistical correlations between quality traits of Great Northern bean and NIR spectra 22

3.1 Number of lines, locations and tests for black bean evaluated for canning quality 42

3.2 Number of lines, locations and tests for Great Northern bean evaluated for canning quality 43

3.3 Number of lines, locations and tests for navy bean evaluated for canning quality 44

3.4 Number of lines, locations and tests for pink bean evaluated for canning quality 45

3.5 Number of lines, locations and tests for pinto bean evaluated for canning quality 46

3.6 Number of lines, locations and tests for red bean evaluated for canning quality 47

3.7 Number of lines, locations and tests analyzed for canning quality of minor market classes of dry bean 48

3.8 Number of lines, locations and tests for field pea, chickpea and lentil evaluated for canning quality 49

5.1 Market classes, including the number of lines, locations and tests, analyzed for composition 60

5.2 Folate contents of dry bean samples as determined by a microbiological assay 61

5.3 Folate contents of lentil samples as determined by a microbiological assay 61

5.4 Folate contents of green pea samples as determined by a microbiological assay 62

5.5 Folate contents of yellow pea samples as determined by a microbiological assay 63

6.1 List of spices, treatments and tests evaluated between 1996 and 2001 66

1. Introduction

Production of the major specialty crops in Saskatchewan has doubled in the past five years (1997-2001). In 2001, the area seeded to specialty crops increased to 18% of the total seeded acreage in the province (which was estimated to be 14.35 million hectares), which represents a 530% increase in the area seeded to specialty crops since 1991. According to Agriculture and Agri-Food Canada (2002), in 2001 Saskatchewan produced most of the pulse and special crops (67% of dry pea, 98% of lentil, 96% of chickpea, 90% of mustard seed and 86% of canary seed) in Canada. Coriander and caraway are the major spice crops, with 6100 hectares (4,000 tonnes) and 4,000 hectares (1,300 tonnes), respectively, harvested in 2001 (Saskatchewan Agriculture and Food, 2002).

Over the past five years, the canning, cooking, visual and nutritional quality of pulses, and the concentration and composition of essential and fixed oils in spices, were evaluated to determine differences in quality among cultivars and locations and the impact of variety x location interactions on quality. Results were used by plant breeders to assist in making their selections, and were incorporated in various reports, publications and presentations. Several new quality evaluation methodologies were developed for assessing the canning quality of dry bean, with the advantages of being faster, which reduces cost and labour requirements, and requiring less sample than the standard canning protocol. Nutritional profiles of selected pulse samples were determined, and a method for quantifying folic acid in starchy legumes was developed. The results from the previous progress reports (five in total) are summarized in this report.

2. Assessment of Methods for the Canning Quality of Dry Bean (*Phaseolus vulgaris* L.)

Dry edible bean (*Phaseolus vulgaris* L.) is probably the most widely grown food legume crop in the world. According to Food and Agriculture Organization (FAO) of the United Nations (2002), 51.5 million tonnes of pulse crops were produced in the world in 2001 of which dry bean represented 16.8 million tonnes. Canadian production of dry bean almost doubled from 136,000 tonnes in 1991 to 268,000 tonnes in 2000. However, production of dry bean in Canada decreased by 5% to 255,000 tonnes in 2001, largely because of drought in Saskatchewan and Alberta and insufficient moisture in Ontario. Canadian production of dry bean was worth more than 175 million dollars in 2001. For 2002, total area seeded to dry bean in Canada is forecast to increase by 34% to 205,000 hectares, and total Canadian production to increase by 39% to 355,000 tonnes, from 2001 (Agriculture and Agri-Food Canada, 2002).

With the increasing importance of legumes in human nutrition, improved breeding, agronomy and quality of pulse crops are more important than ever before. One of the most important parameters in pulse breeding programs is post-harvest quality. Among quality parameters (chemical composition, colour, size, shape, flavour, taste, etc.), the texture of cooked bean is probably the most important to bean processors and consumers. The post-harvest quality of dry edible bean has traditionally been determined directly by measuring the quality traits of canned bean produced according to a standard canning protocol using 14 fl oz cans. Such canning tests are quite expensive, labour intensive and time-consuming. Furthermore, quantities of seed available from co-operative and regional trials of new varieties are usually quite limited and insufficient for such a canning procedure. Because of these limitations of the standard canning protocol,

the development of alternate quality evaluation methods was a major component of this project.

The objective of this study was to assess, modify and/or develop quality evaluation methods for dry bean. Primary considerations in carrying out this study were:

i) minimum seed sample requirement;

ii) appropriate processing conditions (time, temperature, etc.);

iii) reproducibility;

iv) ability to distinguish between cultivars and samples differing in quality.

The study was conducted in three stages:

i) development of new canning protocols using smaller cans;

ii) development of alternative (non-canning) quality evaluation methods;

iii) development of a near infrared reflectance spectroscopy (NIRS) method for assessing canning quality.

2.1 Development of New Canning Protocols Using Smaller Cans

The objectives of this study were: i) to modify the existing laboratory canning protocol in order that quality differences among different bean types might be better distinguished; and ii) to develop a canning protocol having a significantly reduced processing time and requiring a smaller amount of sample. The quantities of seed available from breeding programs are often limited and insufficient for the standard

canning protocol using 14 fl oz cans. Therefore, development of a new laboratory canning protocol utilizing a smaller size of can was necessary for evaluation of quality traits of dry bean during the early stages of the plant breeding process. The study was designed to utilize three smaller sizes of cans, 10, 7 and 4 fl oz, and attempted to match the quality parameters obtained using the standard 14 fl oz cans by modifying soaking time, and retort temperature and time. By utilizing smaller cans and a modified canning protocol, savings in time and resources were achieved.

2.1.1 Results and Discussion

The quality of two commercial cultivars each of navy bean, pinto bean and Great Northern bean from the 1999 crop year was evaluated in this study. Smaller cans, 10 fl oz (211 x 400), 7 fl oz (211 x 214) and 4 fl oz (214 x 211), were utilized to determine if results similar to those obtained using 14 fl oz (300 x 400) cans could be achieved. Hydration coefficient (HC), percent washed drained weight (PWDWT), degree of clumping (CP), appearance (AP), bean colour, and texture (firmness) were determined for soaked/canned seed. The texture of cooked beans was determined using a Kramer Texture Test System (Food Technology Corporation, Rockville, MD) and the results were expressed on a kg 100 g^{-1} basis. The 4 fl oz cans contained less than 100 g of cooked bean seed, the quantity desired in the measurement of the texture of beans when processed in 7, 10 or 14 fl oz cans. Therefore, sample size was reduced to 50 g of cooked beans and texture was reported on a kg 50 g^{-1} basis; for comparative purposes, the texture of 50 g of a control sample, processed in 14 fl oz cans, was determined. The

standard canning protocol and modified canning protocols for canning and evaluating dry bean as used in this study were described in detail in the third progress report (Arganosa et al., 2000).

Results from studies employing 10, 7 and 4 fl oz cans were promising, and were presented in the third and fourth progress reports (Arganosa et al., 2000, 2001). Prior to canning of bean seed, the chemical composition of each bean sample was determined. No significant differences were observed in the chemical composition of bean cultivars in the same market class (data not shown). Therefore, chemical composition and quality traits of bean seed showed no distinct correlations with textural quality within a market class. **Table 2.1** shows the processing parameters employed in the modified canning protocols used in this study, i.e. sample weight, soaking time, retort temperature and retort time. The texture of bean seed from 14 fl oz cans, processed according to the standard laboratory canning protocol, was considered as the reference texture.

The quality traits (HC, PWDWT, CP, AP and color) of canned beans using the standard canning protocol are presented in **Table 2.2**. No distinct correlations between HC and PWDWT were observed. Also, no correlations were detected between either HC or PWDWT and texture. The texture of canned bean, however, did exhibit significant differences among cultivars within the same market classes. In pinto and navy bean, Pinnacle and Envoy exhibited substantially firmer texture than did Camino and Laser, respectively. Two cultivars of Great Northern bean, however, exhibited only slight differences in canned bean texture.

Since quality traits were not correlated with the texture of canned bean, processing time and temperature for smaller cans (4, 7 and 10 fl oz) were altered in an attempt to achieve quality levels similar to those obtained with the standard laboratory canning protocol (**Table 2.1**). **Fig. 2.1**, for example, illustrates the texture (firmness) of the Crocus cultivar of Great Northern bean canned in 4 fl oz cans under a variety of conditions. Texture (kg 50 g^{-1} seed) versus retort time exhibited a linear relationship. The texture of the control fell within the range of textures measured; therefore, it was possible to match the texture of beans canned in 14 fl oz cans to that of beans canned in 4 fl oz cans. For example, in Great Northern bean, the texture of the control matched that of beans retorted for 38 min at 115.6°C or 24 min at 121°C using 4 fl oz cans. **Fig. 2.2** shows, as another example, the linear relationship between texture (kg 100 g^{-1} seed) and retort time for the Laser cultivar of navy bean canned in 7 fl oz and 10 fl oz cans under a variety of conditions. The effect of soak time (16 or 0.5 h) did not significantly affect the texture of canned navy bean, possibly because of its smaller seed size. Retort temperature (115.6° or 121°C) significantly affected the texture of bean seed regardless of the size of can.

Tables 2.3 and **2.4** show the retort times required for beans in three smaller-sized cans to match the textural quality of control samples (14 fl oz cans) under various canning conditions. Generally, the higher the retort temperature, the shorter the retort time required to match the texture of the control. For all three bean market classes, both can size and retort temperature impacted the retort time required. Soak time, however, had no effect on the texture of beans processed at a particular retort temperature, with the exception of pinto bean processed at 115.6°C. For pinto bean, Camino required a

significantly longer processing time (38 min) in 4 fl oz cans than did Pinnacle (33 min) at the lower retort temperature (115.6°C) (**Table 2.3**). For navy and Great Northern bean, the retort time required to match the texture of the control was not significantly different among cultivars or can sizes. At a retort temperature of 121°C (**Table 2.4**), can size and soak time did not significantly affect the texture of canned bean seed. Hence, it was possible to reduce the amount of bean seed required in canning quality tests, from 96 g (dry basis) for 14 fl oz cans to 37 g (dry basis) for 4 fl oz cans, and it was possible to match the texture of beans processed in 14 fl oz cans with that of beans processed in smaller-sized cans, and to differentiate between market classes (**Tables 2.4**).

Although a significant reduction in sample requirement (61% reduction for 4 fl oz cans), soak time (15.5 h) and retort time (50%) was achieved in this study, the canning of dry bean is still a laborious, time consuming, and expensive method for determining bean cooking quality, and an alternative method for assessing canning quality would be desirable.

A paper entitled "Canning quality of dry beans (*Phaseolus vulgaris* L.)" was presented at the 86th Annual Meeting of the American Association of Cereal Chemists (AACC) in Charlotte, NC in October, 2001, and at Pulse Days 2002 in Saskatoon, SK in January, 2002. A manuscript entitled "Modification of canning protocols for determining quality of dry beans (*Phaseolus vulgaris* L.)" has been drafted and will be submitted to the Canadian Journal of Plant Science in the near future.

Table 2.1 Modified canning protocol used in this study.

Can size (fl oz)	Bean weight (g, dry basis)	Soak time (h)	Retort temperature (°C)	Retort time (min)
14 (Control)	96	16.0	115.6	45
		0.5		45
10	68	16.0	115.6	35, 40, 45
		0.5		
		16.0	121.0	15, 20, 25
		0.5		
7	47	16.0	115.6	30, 35, 40
		0.5		
		16.0	121.0	15, 20, 25
		0.5		
4	35	16.0	115.6	30, 35, 40
		0.5		
		16.0	121.0	15, 20, 25
		0.5		

Table 2.2 Quality traits of canned beans using the standard processing protocol[z].

Quality traits	Pinto		Navy		Great Northern	
	Camino	Pinnacle	Envoy	Laser	US 1140	Crocus
HC[y]	2.1a[s]	2.1a	1.9b	2.0ab	1.9bc	2.2ac
PWDWT[x]	70.5a	66.4b	67.9b	67.3b	69.2c	69.8c
CP[w]	2.0	3.0	3.0	2.0	1.0	3.0
AP[v]	2.0	5.0	3.0	3.0	4.0	5.0
Colour[u], L	29.9a	27.0a	48.3b	49.9b	49.4b	48.1b
Colour, a	7.0a	7.5a	3.5b	3.6b	4.6c	5.1c
Colour, b	7.9a	6.9a	10.6b	12.1b	13.4c	12.9c
Texture[t]	33.1a	58.2b	75.5a	35.3b	33.1a	37.3b

[z] Beans were processed under the following conditions: can size of 14 fl oz; blanched at 88°C for 30 min; retort temperature of 115.6°C; retort time of 45 min. Values are means of the at least duplicate determinations.

[y] Hydration coefficient.

[x] Percent washed drained weight (%).

[w] Degree of Clumping.

[v] Degree of Appearance.

[u] L: lightness-darkness; a: redness-greenness; b: yellowness-blueness.

[t] Texture (kg $100g^{-1}$ of canned bean).

[s] Values followed by same letter are not significantly different within the same bean classes. ($P>0.05$)

Table 2.3 Proposed retort times (min) for various sizes of cans at a retort temperature of 115.6°C [z].

Can size (fl oz)	Soak time (h)	Pinto		Navy		Great Northern	
		Camino	Pinnacle	Envoy	Laser	US 1140	Crocus
10	16.0	41a[y]	41a	41a	36b	38a	38a
	0.5	38a	41a	35b	36b	38a	38a
7	16.0	41a	41a	41a	36b	38a	38a
	0.5	38a	41a	35b	36b	38a	38a
4	16.0	38a	33b	32c	34bc	37a	38a
	0.5	38a	33b	32c	34bc	37a	38a

[z] Values are means of the at least duplicate determinations.

[y] Values followed by same letter are not significantly different within the same bean classes. (P>0.05)

Table 2.4 Proposed retort times (min) for various sizes of cans at a retort temperature of 121°C [z].

Can size (fl oz)	Soak time (h)	Pinto		Navy		Great Northern	
		Camino	Pinnacle	Envoy	Laser	US 1140	Crocus
10	16.0	24a[y]	24a	23a	23a	24a	24a
	0.5	23a	22a	20ab	23a	24a	24a
7	16.0	23a	24a	23a	23a	24a	24a
	0.5	24a	22a	20ab	23a	24a	24a
4	16.0	23a	22a	19b	19b	24a	24a
	0.5	23a	22a	19b	19b	24a	24a

[z] Values are means of the at least duplicate determinations.

[y] Values followed by same letter are not significantly different within the same bean classes. (P>0.05)

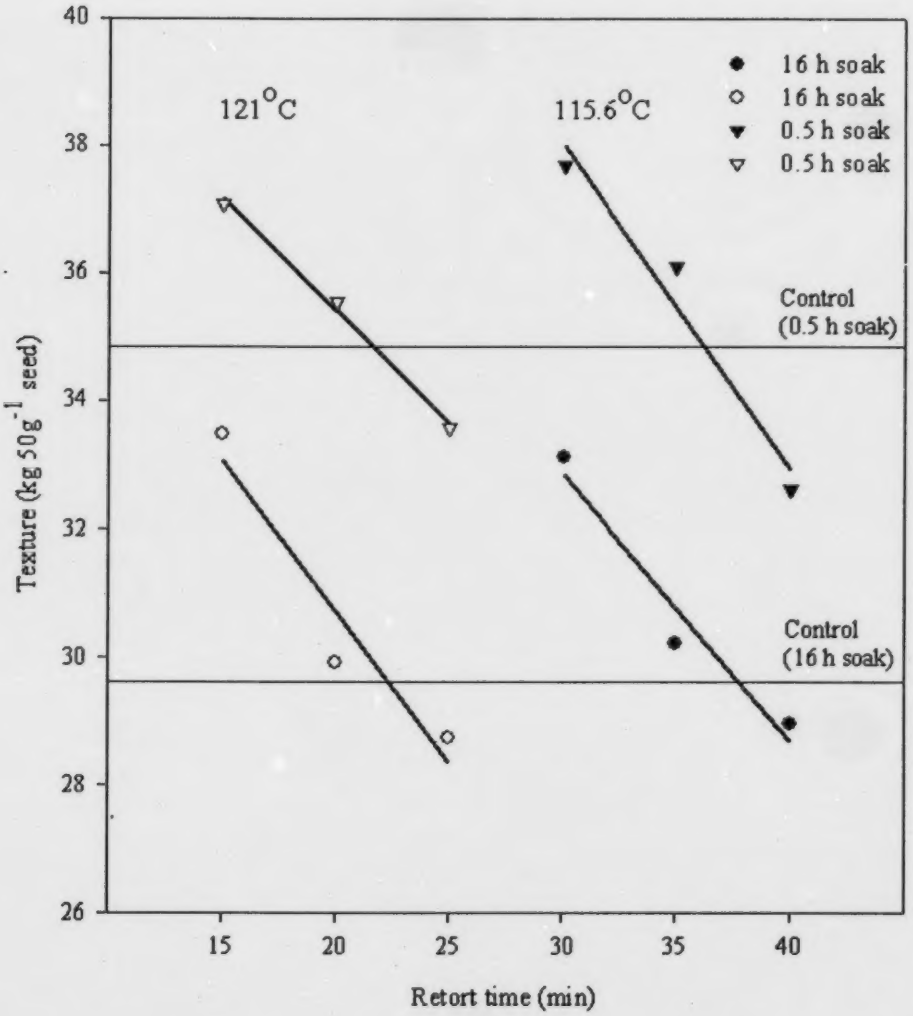

Figure 2.1 Texture of Great Northern bean (cv. Crocus) canned in 4 fl oz can under various conditions.

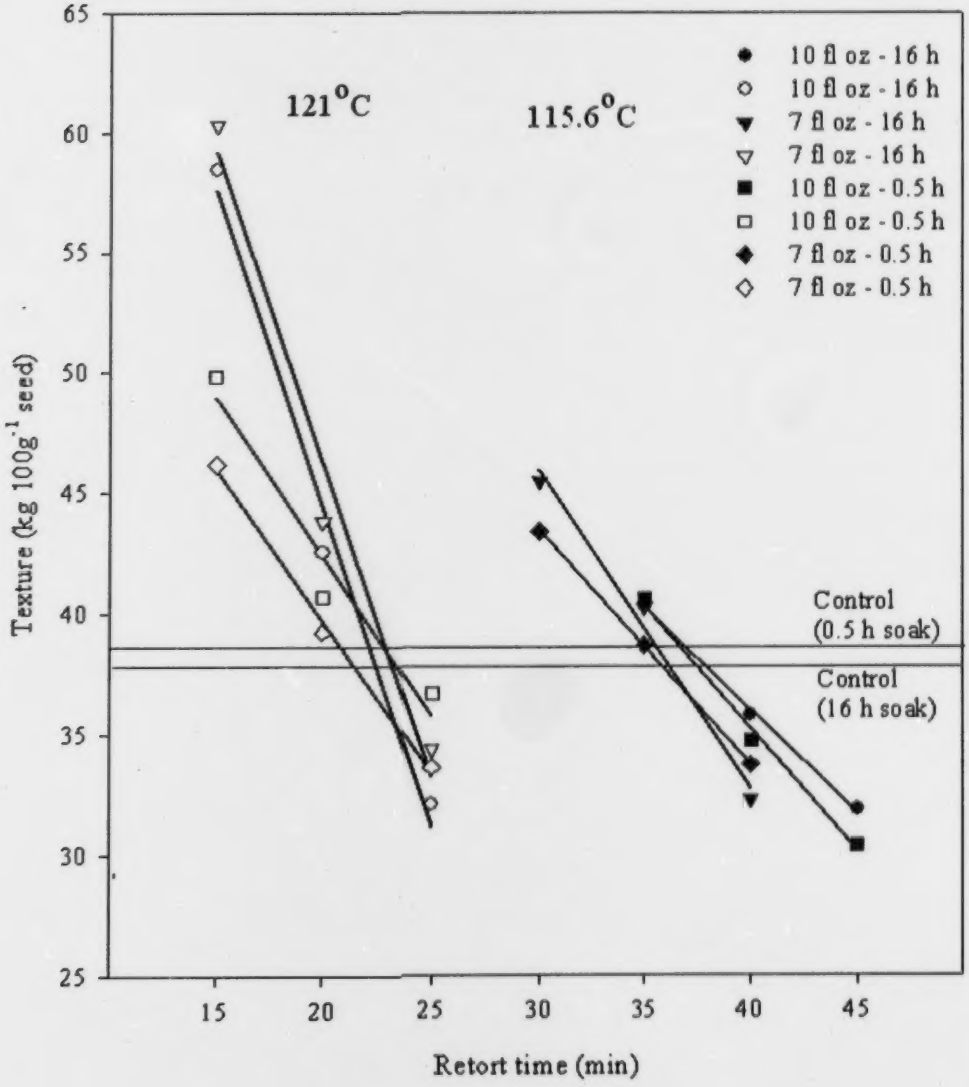

Figure 2.2 Texture of navy bean (cv. Laser) canned in 7 and 10 fl oz cans under various conditions.

2.2 Development of Alternative (Non-canning) Quality Evaluation Methods

The objective of the second phase of this study was to develop quality testing methods which could be used as alternatives to the canning method. Although the amount of seed, cost and time for quality testing were considerably reduced using a new canning protocol and smaller cans, the high cost of cans and the requirement for two weeks of storage of canned bean prior to quality testing were significant disadvantages of this method. Therefore, the development of non-canning quality evaluation methods was studied. It was essential that these methods meet the quality profiles of bean determined by the canning process, and that they also meet the four criteria mentioned earlier.

2.2.1 Results and Discussion

Mattson cooker and quick-cooking tests were successfully developed to measure the textural quality of dry beans without canning. The Mattson experimental laboratory bean cooker, developed by Mattson (1946), was used in this study. Details of the method and results from this study were presented in the second and third progress reports (Arganosa et al., 1999, 2000). The main advantage of the Mattson cooker method is its small sample requirement of only twenty-five seeds. A problem with the Mattson cooker method has been a bias in the results because of the number of hard-to-cook seeds present in a twenty-five seed sample. However, by measuring the elapsed time from the initiation of cooking until penetration of thirteen of the twenty-five seeds, and by conducting the experiment in triplicate at least, the bias caused by hard-to-cook

seeds was effectively eliminated. A quick-cooking test was also developed which used a relatively small amount of seed (10 g) and a short cooking time (20 min). The texture of cooked beans was then determined using the Kramer Texture Test System (Food Technology Corporation, Rockville, MD). Samples were analyzed in triplicate, and the results were expressed as kg 10 g^{-1} seed. Details of both testing methods were included in the second progress report (Arganosa et al., 1999).

For the Mattson cooker method, cooking time indices for two cultivars of each of three bean classes were calculated. The cooking time indices were significantly different among cultivars within bean classes. Among the three market classes, the cooking time indices of pinto and Great Northern bean were similar, whereas that of navy bean was considerably higher. A significant difference in texture between the two cultivars in each bean class was also found by the quick-cooking testing method. The correlation coefficients for the Mattson cooker method and the quick-cooking method against the canning quality method were 0.79 and 0.77, respectively. Considering the variables associated in these quality testing methods, the correlation coefficients were reasonable. The merits of the two methods were the significant savings in analysis time and cost. However, replacing the canning method with the Mattson cooker or the quick-cooking method would be hindered by their relatively low correlation against the canning method and the relative tediousness of both methods. These testing methods may be utilized for quality testing of early breeding lines where the amount of available seed is quite limited.

2.3 Development of a Method for Assessing Canning Quality Using Near Infrared Reflectance Spectroscopy (NIRS)

In the final phase of this study, a near infrared reflectance spectroscopy (NIRS) method was developed for predicting the canning quality of dry bean. NIRS has been used widely in the grain industry as a fast, non-destructive and convenient means of determining the composition of grains for over thirty years, and is used in many countries for routine quality testing (moisture, protein, lipid, etc.) of grain samples. If a correlation could be found between the NIR spectrum and the cooking quality of beans (as determined by the canning method), NIRS could be used to estimate the cooking quality of beans with less time, cost, labour and amount of sample.

2.3.1 Results and Discussion

Nearly four hundred dry bean samples of different cultivars of navy, red, pinto, black, pink and Great Northern bean, grown in six different locations in Saskatchewan in 2000, were scanned using an NIR Spectrometer (FOSS NIRSystem, Inc., Silver Spring, MD) and their NIR spectra (400-2498 nm wavelength range) were determined. The NIR data were compared to canning quality data and statistics were generated. The canning method, quality results and NIRS scanning procedure were described in the fourth and fifth progress reports (Arganosa et al., 2001, 2002).

Tables 2.5 through **2.10** present the results obtained from the statistical comparison of quality traits for each bean market class and their NIR spectra. Hydration coefficient (HC), percent washed drained weight (PWDWT) and texture were the quality

traits compared. Other quality traits (e.g. clumping and appearance) were not used in this study because of the subjective nature of their methodologies. Bean colour also was not used because of its negligible variance within each market class (Arganosa et al., 2001). The regression analysis of each bean class was expressed as two parameters: the coefficient of determination (RSQ) and one minus the variance ratio (1-VR). According to the definitions of the two parameters, the correlations between quality traits and NIR spectra is greater with higher values of RSQ and 1-VR.

In **Table 2.5**, the texture of canned navy bean shows a high correlation value for both RSQ and 1-VR against the NIR spectrum; however, relatively small 1-VR correlation values were found for HC and PWDWT. Therefore, it was concluded that the NIR spectrum could reliably predict the texture of canned navy bean, but not HC or PWDWT. Similar relationships between the texture of canned beans and NIR spectra were found in the other bean market classes, except in the case of Great Northern bean which had a 1-VR value for texture of 0.38 (**Tables 2.6** through **2.10**). Since only thirty-three samples of Great Northern bean were used in this study, this correlation might be improved by the analysis of additional samples (**Table 2.10**). Hydration coefficients for black and pinto beans showed relatively high 1-VR values (0.70 and 0.65, respectively). However, large variations in 1-VR values were observed among bean market classes, and it is premature to draw any conclusions without analyzing additional bean samples (**Tables 2.6** and **2.7**).

Prediction of the texture of canned bean using NIRS looks very promising at this point. However, reliable application of NIRS will require calibration from a large pool

of representative bean samples. To eliminate bias in the NIRS calibration, calibration samples should be obtained from several varieties grown at several locations in several crop years. The collection and scanning of additional dry bean samples from the 2001 crop year is in progress. Considering the high cost, labour requirements and time-consuming nature of canning studies, NIRS could be an economical and convenient way to predict the textural quality of cooked bean for breeders and processors.

The results of this study will be presented as a poster entitled "Determination of the Canning Quality of Dry Beans using Near Infrared Reflectance Spectroscopy (NIRS)" at the 87th Annual Meeting of the American Association of Cereal Chemists (AACC) in Montreal, PQ in October, 2002.

Table 2.5 Statistical correlations between quality traits of navy bean and NIR spectra.

	Hydration Coefficient	Percent Washed Drained Weight	Texture
RSQ[1]	0.94	0.97	0.95
1 - VR[2]	0.34	0.30	0.81

1 Correlation coefficient of determination

2 One minus the variance ratio

Table 2.6 Statistical correlations between quality traits of black bean and NIR spectra.

	Hydration Coefficient	Percent Washed Drained Weight	Texture
RSQ[1]	0.80	0.56	0.84
1 - VR[2]	0.70	0.41	0.69

1 Correlation coefficient of determination

2 One minus the variance ratio

Table 2.7 Statistical correlations between quality traits of pinto bean and NIR spectra.

	Hydration Coefficient	Percent Washed Drained Weight	Texture
RSQ[1]	0.81	0.39	0.86
1 - VR[2]	0.65	0.32	0.76

1 Correlation coefficient of determination

2 One minus the variance ratio

Table 2.8 Statistical correlations between quality traits of red bean and NIR spectra.

	Hydration Coefficient	Percent Washed Drained Weight	Texture
RSQ[1]	0.79	0.86	0.94
1 - VR[2]	0.57	0.58	0.84

1 Correlation coefficient of determination

2 One minus the variance ratio

Table 2.9 Statistical correlations between quality traits of pink bean and NIR spectra.

	Hydration Coefficient	Percent Washed Drained Weight	Texture
RSQ[1]	0.86	0.97	0.83
1 - VR[2]	0.28	0.18	0.70

1 Correlation coefficient of determination

2 One minus the variance ratio

Table 2.10 Statistical correlations between quality traits of Great Northern bean and NIR spectra.

	Hydration Coefficient	Percent Washed Drained Weight	Texture
RSQ[1]	0.76	0.89	0.71
1 - VR[2]	0.35	0.56	0.38

1 Correlation coefficient of determination

2 One minus the variance ratio

2.4 Recommendations

The modified canning protocol employing 4 fl oz cans is available for immediate use. It is anticipated that, over time, this test will be widely employed, especially for early-generation lines, due to the small sample size required. An additional period of familiarization may be required as breeders/quality technicians will need to develop confidence in the new method.

Although the alternative (non-canning) quality evaluation methods, namely the Mattson cooker method and the quick-cooking method, exhibited reasonably high correlation coefficients (0.79 and 0.77, respectively) against the texture of corresponding canned bean samples, their practical use, if any, would be limited to quality screening in the early stages of bean breeding when the availability of seed is exceedingly limited and canning data cannot be generated at all. It is not anticipated that these alternative methods will ever find general use, as their correlation to canning methods is just not high enough.

Preliminary results from the NIRS study are very encouraging, although further analysis is required to generate calibrations of practical use. If the effectiveness of NIRS for predicting the texture of canned beans is confirmed, this non-destructive, convenient, cost effective and rapid testing method could be used by both breeders and processors, despite the substantial initial investment required for instrumentation. Providing regularly updated calibrations for NIRS may become a source of cost recovery, since the calibrations could be protected as intellectual property. The potential for using NIRS to

evaluate the canning quality of bean is enormous, and it may be that NIRS will replace the canning method for quality evaluation of dry beans in the future.

2.5 References

Agriculture and Agri-Food Canada (AAFC). 2002. Supply and disposition for special crops. In *Canada: Special crops situation and outlook*. Strategic Policy Branch, Market Analysis Division, AAFC, Winnipeg, Manitoba, Canada.

Arganosa, G. C., Tyler, R. T., Han, J. Y. and Rowland, G. G. 2000. Progress Report No. 3. Quality Evaluation and research in support of spice and pulse crop breeding projects (Project #96000303). Supported by the Agri-Food Innovation Fund (AFIF), Regina, SK.

Arganosa, G. C., Tyler, R. T., Han, J. Y. and Rowland, G. G. 2001. Progress Report No. 4. Quality Evaluation and research in support of spice and pulse crop breeding projects (Project #96000303). Supported by the Agri-Food Innovation Fund (AFIF), Regina, SK.

Arganosa, G. C., Tyler, R. T., Han, J. Y. and Rowland, G. G. 2002. Progress Report No. 5. Quality Evaluation and research in support of spice and pulse crop breeding projects (Project #96000303). Supported by the Agri-Food Innovation Fund (AFIF), Regina, SK.

Food and Agriculture Organization (FAO). 2002. FAOSTAT Agriculture Data. FAO Statistical data base. http://apps.fao.org/page/collections?subset=agriculture.

Hruschka, W. R. 2001. Data analysis: Wavelength selection methods. In Near-Infrared Technology in the Agricultural and food industries. 2nd ed. Ed P. Williams and K. Norris. American Association of Cereal Chemists. St. Paul, MN. pp: 39-58.

Mattson, S. 1946. The cookability of yellow peas. A colloid-chemical and biochemical study. Acta. Agric. Suec. 2:185.

3. Canning Quality of Pulses

3.1 Canning Quality of Dry Bean

3.1.1 Canning Quality of Black Bean

Table 3.1 lists the black bean lines evaluated in 1999, 2000 and 2001. Values for the individual varieties and locations for each trial can be found in previous progress reports (Arganosa et al., 2000, 2001, 2002).

In 1999, one line, HR 21 DL, from the 1999 Manitoba Cooperative Trials, was found to possess canning quality similar to that of the check variety, AC Harblack. One line, L95F025, from the 1999 Narrow Row Cooperative Trials, was found to possess canning quality similar to those of the check cultivars, CDC Nighthawk and UI906. Significant variety x location interactions were observed for Hunterlab 'L' and 'b' values for uncooked seed, Hunterlab 'a' values for cooked seed, hydration coefficient (HC) and texture. One line, L96F101, from the 1999 Wide Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, UI906. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for cooked seed, percent washed drained weight (PWDWT) and texture. One line, CDC Expresso, from the 1999 Bean Regional Trials, was found to possess canning quality similar to that of the check cultivar, CDC Nighthawk. Significant variety x location interactions were observed for HC and texture.

In 2000, one line, L95F101, from the 2000 Bean Regional Trials, was found to possess canning quality similar to that of the check cultivar, CDC Expresso. Significant variety x location interactions were found for HC and texture. Two lines, Onyx and 318-51, from the 2000 Manitoba Bean Cooperative Trials, were found to possess canning

quality similar to that of the check cultivar, AC Harblack. Significant variety x location interactions were observed for HC. Three lines, 315-18BK, 316-13BK and 321-9BK, from the 2000 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivars, CDC Nighthawk and UI906. Significant variety x location interactions were observed for Hunterlab 'L' and 'b' values for uncooked seed, Hunterlab 'a' values for cooked seed, HC, PWDWT, appearance and texture. Two lines, 316-12 and L96F101, from the 2000 Wide Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, UI906. Significant variety x location interactions were observed for Hunterlab 'a' and 'b' values for cooked seed, HC, PWDWT and texture.

In 2001, one line, 316-11, from the 2001 Narrow Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivars, CDC Nighthawk and UI906. A significant variety x location interaction was found for PWDWT only.

3.1.2 Canning Quality of Great Northern Bean

Table 3.2 lists the Great Northern bean lines evaluated between 1997 and 2001. Values for the individual lines and locations for each trial can be found in previous progress reports (Arganosa et al., 1998, 1999, 2000, 2001, 2002).

In 1997, two lines, 93128 and 93407, from the 1997 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, US1140. Significant variety x location interactions were observed for

Hunterlab 'L' and 'b' values for uncooked seed, Hunterlab 'L' values for cooked seed, HC and texture. Two lines, CDC Nordic and 92074, from the 1997 Bean Regional Trials, were found to possess canning quality similar to that of the check cultivar, US1140. Significant variety x location interactions were found for Hunterlab 'b' values for uncooked seed, Hunterlab 'a' values for cooked seed, HC and texture.

In 1998, three lines, 93407, Generatif and 201-25LL, from the 1998 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, CDC Nordic. Significant variety x location interactions were observed for Hunterlab 'a' values for uncooked seed, HC and texture.

In 1999, four lines, 201-25LL, L95E101, L96E108 and 165-11, from the 1999 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivars, US1140 and CDC Nordic. Significant variety x location interactions were found for Hunterlab 'b' values for uncooked seed, HC and texture. Three lines, 92074, 93128 and 93407, from the 1999 Bean Regional Trials, were found to possess canning quality similar to that of the check cultivars, US1140 and CDC Nordic. Significant variety x location interactions were found for Hunterlab 'b' values for uncooked seed, HC and texture.

In 2000, four lines, CDC Bianca, CDC Crocus, 93407 and AC Polaris, from the 2000 Bean Regional Trials, were found to possess canning quality similar to that of the check cultivar, US1140. Significant variety x location interactions were observed for Hunterlab 'a' and 'b' values for cooked seed, HC, appearance and texture. Two lines, L96E109 and 93-155-15, from the 2000 Manitoba Bean Cooperative Trials, were found

to possess canning quality similar to that of the check cultivar, US1140. Significant variety x location interactions were observed for HC and texture. One line, CDC Crocus, from the 2000 Narrow Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, US1140. Significant variety x location interactions were observed for Hunterlab 'b' values for uncooked seed. One line, L96E108, from the 2000 Wide Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, US1140. Significant variety x location interactions were found for Hunterlab 'a' values for cooked seed, HC, PWDWT, clumping and texture.

In 2001, two lines, CDC Crocus and L98E212, from the 2001 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, US1140. Significant variety x location interactions were observed for Hunterlab 'a' values for both uncooked and cooked seed, HC, PWDWT and texture.

3.1.3 Canning Quality of Navy Bean

Table 3.3 lists the navy bean lines evaluated in 1997, 1999, 2000 and 2001. Values for the individual lines and locations for each trial can be found in previous progress reports (Arganosa et al., 1999, 2000, 2001, 2002).

In 1997, one line, GTS 523, from the 1997 Bean Regional Trials, was found to possess canning quality similar to that of the check cultivar, AC Skipper. Significant variety x location interactions were observed for Hunterlab 'L' and 'a' values for both uncooked and cooked seed, HC and appearance. Two lines, L94A001 and 92661LL,

from the 1997 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, AC Skipper. Significant variety x location interactions were observed for Hunterlab 'b' values for uncooked seed, Hunterlab 'L', 'a' and 'b' values for cooked seed and HC.

In 1999, four lines, 92661, L95A035, T9601 and HR71, from the 1999 Manitoba Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Envoy. Significant variety x location interactions were observed for Hunterlab 'L' and 'b' values for uncooked seed and HC.

In 2000, one line, 92661, from the 2000 Bean Regional Trials, was found to possess canning quality similar to that of the check cultivar, AC Skipper. Significant variety x location interactions were observed for Hunterlab 'b' values for uncooked seed. Two lines, ROG 331 and ROG 372, from the 2000 Manitoba Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Envoy. Significant variety x location interactions were observed for Hunterlab 'a' and 'b' values for cooked seed, HC and PWDWT. One line, Minerva, from the 2000 Narrow Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivars, AC Skipper and Envoy. Significant variety x location interactions were observed for Hunterlab 'a' and 'b' values for uncooked seed, Hunterlab 'b' values for cooked seed, HC and appearance.

In 2001, two lines, Minerva and 325-28, from the 2001 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivars, AC Skipper and Envoy. Significant variety x location interactions were

observed for Hunterlab 'L', 'a' and 'b' values for both uncooked and cooked seed, HC, PWDWT, appearance and texture. Four lines, L97A246, Voyager, L94A0001 and L97A235, from the 2001 Manitoba Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Envoy. Significant variety x location interactions were found for Hunterlab 'a' and 'b' values for uncooked seed, Hunterlab 'b' values for cooked seed, HC and texture.

3.1.4 Canning Quality of Pink Bean

Table 3.4 lists the pink bean lines evaluated between 1997 and 2001. Values for the individual lines and locations for each trial can be found in previous progress reports (Arganosa et al., 1998, 1999, 2000, 2001, 2002).

In 1997, one line, 93318, from the 1997 Narrow Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for uncooked seed, Hunterlab 'b' values for cooked seed and texture. One line, L94C274, from the 1997 Wide Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were found for Hunterlab 'L' values for uncooked seed and Hunterlab 'L' and 'a' values for cooked seed.

In 1998, two lines, L94C356 and 95-34-6PK, from the 1998 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were observed for Hunterlab

'a' and 'b' values for uncooked seed, Hunterlab 'L', 'a' and 'b' values for cooked seed, HC, appearance and texture.

In 1999, one line, 93318, from the 1999 Narrow Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were observed for Hunterlab 'L' values for uncooked seed and texture. Two lines, L96C104 and AC Alberta Pink, from the 1999 Wide Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were observed for Hunterlab 'L' values for uncooked seed, HC, appearance and texture. Two lines, 93318 and 95-34-6PK, from the 1999 Bean Regional Trials, were found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were found for Hunterlab 'L' values for uncooked seed, Hunterlab 'a' values for cooked seed and texture.

In 2000, two lines, CDC Rosa and 95-34-6PK, from the 2000 Bean Regional Trials, were found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were observed for Hunterlab 'L' and 'b' values for uncooked seed and HC. Two lines, 93175-4PK and 95-19-4PK, from the 2000 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were found for Hunterlab 'L' values for uncooked seed, appearance and texture.

In 2001, three lines, 504AA-8, L98C287 and L98C280, from the 2001 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of

the check cultivar, Viva. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for uncooked seed, HC, PWDWT and texture. One line, L94C356, from the 2001 Manitoba Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, Viva. Significant variety x location interactions were observed for Hunterlab 'b' values for cooked seed, HC and texture.

3.1.5 Canning Quality of Pinto Bean

Table 3.5 lists the pinto bean lines evaluated between 1997 and 2001. Values for the individual varieties and locations for each trial can be found in previous progress reports (Arganosa et al., 1998, 1999, 2000, 2001, 2002).

In 1997, two lines, 93708 and 94138, from the 1997 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Othello. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for uncooked seed, clumping and appearance. Four lines, CDC Camino, AC Burrito, 92802-IiI and 92235, from the 1997 Bean Regional Trials, were found to possess canning quality similar to that of the check cultivar, Othello. Significant variety x location interactions were found for Hunterlab 'L', 'a' and 'b' values for uncooked seed, Hunterlab 'a' and 'b' values for cooked seed, HC, appearance and texture. One line, Winchester, from the 1997 Wide Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, Othello. There were no significant variety x location interactions in this instance.

In 1998, one line, 94138, from the 1998 Narrow Row Bean Cooperative Trials, was found to possess canning quality similar to those of the check cultivars, Othello and CDC Camino. Significant variety x location interactions were observed for Hunterlab 'L' and 'b' values for uncooked seed and Hunterlab 'a' values for cooked seed.

In 1999, five lines, 95-6-1, 95-6-6, L96B101, 95-83-10 and 93-122-10, from the 1999 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivars, Othello and CDC Camino. Significant variety x location interactions were observed for HC. Two lines, 64-68-8 and 95-82-13, from the 1999 Wide Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Othello. Significant variety x location interactions were observed for appearance. Three lines, 92235, 92802A and 93708, from the 1999 Bean Regional Trials, were found to possess canning quality similar to that of the check cultivars, Othello and CDC Camino. Significant variety x location interactions were found for Hunterlab 'L' and 'a' values for uncooked seed and HC.

In 2000, three lines, CDC Pinnacle, CDC Altiro and CDC Pintium, from the 2000 Bean Regional Trials, were found to possess canning quality similar to that of the check cultivars, Othello and CDC Camino. Significant variety x location interactions were observed for Hunterlab 'a' and 'b' values for cooked seed and HC. Four lines, 351-26PT, 354-13PT, 354B-14PT and 95-83-10-PT, from the 2000 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivars, CDC Pintium and Othello. Significant variety x location interactions were observed for HC, PWDWT, appearance and texture. One line, 95-82-13PT, from the 2000 Wide Row Bean Cooperative Trials, was found to possess canning quality similar

to that of the check cultivar, Othello. Significant variety x location interactions were observed for Hunterlab 'L' values for cooked seed and PWDWT.

In 2001, three lines, 335-8, 354B-5 and SC11745-3, from the 2001 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivars, CDC Pintium and Othello. Significant variety x location interactions were observed for Hunterlab 'a' values for both uncooked and cooked seed, HC and texture. Three lines, L98B335, L98B336 and L98B351, from the 2001 Wide Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, Othello. Significant variety x location interactions were observed for Hunterlab 'b' values for uncooked seed.

3.1.6 Canning Quality of Red Bean

Table 3.6 lists the red bean lines evaluated between 1997 and 2001. Values for the individual varieties and locations for each trial can be found in previous progress reports (Arganosa et al., 1998, 1999, 2000, 2001, 2002).

In 1997, one line, 93308, from the 1997 Narrow Row Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, NW63. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for uncooked seed, Hunterlab 'b' values for cooked seed and HC.

In 1998, two lines, L94D007 and L94D156, from the 1998 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, NW63. There were no significant variety x location interactions. Three lines,

L94D153, L94D290 and L94D292, from the 1998 Wide Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, NW63. Significant variety x location interactions were observed for HC.

In 1999, one line, L96D114, from the 1999 Manitoba Bean Cooperative Trials, was found to possess canning quality similar to that of the check cultivar, NW63. Significant variety x location interactions were observed for Hunterlab 'L' values for uncooked seed and Hunterlab 'a' values for cooked seed. Three lines, 296-X-7, L96D112 and L96D113, from the 1999 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check variety, NW63. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for uncooked seed and texture. Two lines, L94D247LE and AC Earlired, from the 1999 Wide Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivar, NW63. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for cooked seed and texture.

In 2000, one line, AC Earlired, was found to possess canning quality similar to that of other market classes of dry bean. Significant differences in Hunterlab 'L', 'a' and 'b' values for both uncooked and cooked seed, HC, appearance and texture were found due to location. Four lines, AC Redbond, 296-X-7, 297-15-R and L97D223, were found to possess canning quality similar to that of the check cultivar, NW63. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for both uncooked and cooked seed, HC, PWDWT, appearance and texture.

In 2001, two lines, L98D333 and L98D347, from the 2001 Narrow Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivars, NW63 and AC Redbond. Significant variety x location interactions were observed for Hunterlab 'b' values for uncooked seed, HC and texture. Three lines, AC Earlired, L98D292 and L98D347, from the 2001 Wide Row Bean Cooperative Trials, were found to possess canning quality similar to that of the check cultivars, NW63 and AC Redbond. Significant variety x location interactions were observed for Hunterlab 'a' values for cooked seed and HC.

3.1.7 Canning Quality of Minor Market Classes of Dry Bean

Table 3.7 lists the number of minor market classes of dry bean evaluated in 2000 and 2001. Values for the individual varieties and locations for each trial can be found in previous progress reports (Arganosa et al., 2001, 2002).

One Flor de Mayo line, 180-5FDM, from the 2000 Narrow Row Bean Cooperative Trials, was found to possess canning quality similar to that of other market classes of dry bean. Significant differences, due to location, in Hunterlab 'L', 'a' and 'b' values for both uncooked and cooked seed, HC, PWDWT and texture were observed.

One golden pinto line from the 2001 Narrow Row Bean Cooperative Trials was found to possess canning quality similar to that of other market classes of dry bean. Significant differences, due to location, in Hunterlab 'L', 'a' and 'b' values for uncooked seed, Hunterlab 'a' and 'b' values for cooked seed, HC, PWDWT, appearance and texture were observed.

One Arikara yellow bean line from the 2001 Wide Row Bean Cooperative Trials was found to possess canning quality similar to that of other market classes of dry bean. Significant differences, due to location, in Hunterlab 'L', 'a' and 'b' values for uncooked seed, Hunterlab 'a' and 'b' values for cooked seed, HC, PWDWT, appearance and texture were observed.

3.2 Canning Quality of Field Pea, Chickpea and Lentil

3.2.1 Canning Quality of Field Pea

Table 3.8 lists the field pea lines evaluated in 1996 and 1997. Values for the individual lines and locations for each trial can be found in previous progress reports (Arganosa et al., 1998, 1999).

Four lines, Obelisque, Olivin, Clipper, and CDC Peko, from the 1996 Field Pea Regional Variety Trials, were found to possess canning quality similar to that of the check cultivar, Keoma. Significant variety x location interactions were observed for Hunterlab 'L' and 'a' values for uncooked seed, Hunterlab 'L', 'a' and 'b' values for cooked seed, HC, PWDWT, clumping, appearance and texture. One line, Explorer, from the 1997 Regional Variety Trials, in addition to Olivin and CDC Peko, which were previously evaluated in 1996, were again found to possess canning quality similar to that of the check cultivar, Keoma. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for both uncooked and cooked seed and HC.

3.2.2 Canning Quality of Chickpea

Table 3.8 lists the chickpea lines evaluated in 1996, 1997 and 1999. Values for the individual lines and locations for each trial can be found in previous progress reports (Arganosa et al., 1998, 2000).

Two lines, 92037-26 and 92066-25, were found to possess canning quality similar to that of the check cultivar, Sanford. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for uncooked seed and HC. Eleven lines, CDC Yuma, CDC Chico, CDC Xena, X39, Evans, 92-67-4, 93-113-59, 93-120-63, 92-009-10, 92-060-11 and 92-014-13, from the 1999 Chickpea Regional Trials, were found to possess canning quality similar to that of the check cultivar, Sanford. Significant variety x location interactions were observed for Hunterlab 'b' values for uncooked seed, Hunterlab 'a' and 'b' values for cooked seed and texture. Ten lines, CDC Yuma, CDC Chico, CDC Xena, Xena-39, Evans, 92-67-4, 93-113-59, 93-120-63, 92-009-10 and 92-060-11, from the 2000 Chickpea Regional Trials, were found to possess canning quality similar to that of the check cultivar, Sanford. Significant variety x location interactions were observed for Hunterlab 'L', 'a' and 'b' values for both uncooked and cooked seed, HC, PWDWT, appearance and texture.

3.2.3 Canning Quality of Lentil

Table 3.8 lists the lentil lines evaluated in 1998. Values for the individual varieties and locations for each trial can be found in a previous progress report (Arganosa et al., 2000).

One line, 578-28, from the 1998 Lentil Cooperative Yield Test, was found to possess canning quality similar to that of the check cultivar, Laird. Significant variety x location interactions were observed for Hunterlab 'L' and 'a' values for uncooked seed. Another line, 638-23, from the 1998 Lentil Cooperative Yield Test, was found to possess canning quality similar to that of the check cultivar, Richlea. There were no significant variety x location interactions observed.

3.3 Conclusions

Methodologies to evaluate the canning quality of different market classes of dry bean, field pea, chickpea and lentil were employed to determine if differences existed among lines and locations and to detect variety x location interactions. Significant differences among lines and locations were found. Significant variety x location interactions also were observed. For all pulses, market classes and years, one or more lines comparable or similar to check varieties were identified.

Table 3.1 Number of lines, locations and tests for black beans evaluated for canning quality.

Lines	Locations	Trial Name	Progress Report No.	Variety[1]	Location[1]	Variety x Location[1] Interaction
2	4	1999 Manitoba Cooperative Trials	3	None	UL, Ub, Tx	None
3	5	1999 Narrow Row Bean Cooperative Trials	3	UL, Ua, Ub, CL, Ca, Cb, HC, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, Ap, Tx	UL, Ub, Ca, HC, Tx
2	5	1999 Wide Row Cooperative Trials	3	Ua, CL, Ca, HC, P, Cl, Ap, Tx	UL, Ua, Ub, HC, P, Tx	CL, Ca, Cb, P, T, Tx
2	3	1999 Bean Regional Trials	4	UL, Ua, Ub, CL, Cb, HC, P, Ap, Tx	UL, Ub, Ca, HC	HC, Tx
2	5	2000 Bean Regional Trials	4	UL, Ub, CL, Ca, Cb, HC, Ap, Tx	UL, HC, Ap, Tx	HC, Tx
3	4	2000 Manitoba Cooperative Trials	4	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, HC, Ap, Tx	HC
5	6	2000 Narrow Row Bean Cooperative Trials	4	Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ub, Ca, HC, P, Ap, Tx
3	3	2000 Wide Row Cooperative Trials	4	Ua, Ub, CL, Ca, Cb, HC, P, Ap	UL, Ua, Ub, Ca, Cb, HC, P, Ap, Tx	Ca, Cb, HC, P, Tx
3	4	2001 Narrow Row Bean Cooperative Trials	5	UL, Ua, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ub, CL, Cb, P, Tx	P
25	**39**	**Totals**				

1 UL=Hunterlab 'L' colour value, uncooked seed; Ua=Hunterlab 'a' colour value, uncooked seed; Ub=Hunterlab 'b' colour value, uncooked seed; CL=Hunterlab 'L' colour value, cooked seed; Ca=Hunterlab 'a' colour value, cooked seed; Cb=Hunterlab 'b' colour value, cooked seed, HC=hydration coefficient; P=percent washed drained weight; Cl=clumping score; Ap=appearance score; Tx=texture. Variables listed in each column indicate significance ($P<0.05$).

Table 3.2 Number of lines, locations and tests for Great Northern bean evaluated for canning quality.

Lines	Locations	Trial Name	Progress Report No.	Variety[1]	Location[1]	Variety x Location[1] Interaction
3	6	1997 Narrow Row Bean Cooperative Trials	1	UL, Ua, Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, Ub, , CL, , Ca, HC, P, Cl, Tx	UL, Ub. , CL, HC, Tx
3	7	1997 Bean Regional Trials	2	UL, Ua, Ub, CL, Ca, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	Ub, Ca, HC, Tx
4	7	1998 Narrow Row Bean Cooperative Trials	2	UL, Ua, Ub, CL, Ca, HC, Tx	UL, Ua, Ub, Ca, HC, P, Ap, Tx	Ua, HC, Tx
6	5	1999 Narrow Row Bean Cooperative Trials	3	UL, Ua, Ub, CL, HC, P, Ap, Tx	UL, Ua, Ub, Ca, Cb, P, Tx	Ub, HC, Tx
5	4	1999 Bean Regional Trials	4	UL, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ap, Tx	Ub, HC, Tx
5	4	2000 Bean Regional Trials	4	UL, Ua, Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	Ca, Cb, HC, Ap, Tx
3	4	2000 Manitoba Cooperative Trials	4	Ua, Ub, Ca, HC, P, Cl, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Tx	HC, Tx
2	6	2000 Narrow Row Bean Cooperative Trials	4	UL, Ua, Ub, CL, Ca, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Tx	Ub
2	5	2000 Wide Row Bean Cooperative Trials	4	UL, Ua, Ca, Cb, HC, Cl, Tx	UL, Ua, Ub, CL, Ca, HC, Cl, Tx	Ca, HC, P, Cl, Tx
3	7	2001 Narrow Row Bean Cooperative Trials	5	UL, Ua, Ub, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Tx	Ua, Ca, HC, P, Tx
36	**55**	**Totals**				

1 UL=Hunterlab 'L' colour value, uncooked seed; Ua=Hunterlab 'a' colour value, uncooked seed; Ub=Hunterlab 'b' colour value, uncooked seed; CL=Hunterlab 'L' colour value, cooked seed; Ca=Hunterlab 'a' colour value, cooked seed; Cb=Hunterlab 'b' colour value, cooked seed, HC=hydration coefficient; P=percent washed drained weight; Cl=clumping score; Ap=appearance score; Tx=texture. Variables listed in each column indicate significance ($P<0.05$).

Table 3.3 Number of lines, locations and tests for navy bean evaluated for canning quality.

Lines	Locations	Trial Name	Progress Report No.	Variety[1]	Location[1]	Variety x Location[1] Interaction
2	7	1997 Bean Regional Trials	2	UL, Ua, Ca, Cb, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, CL, Ca, HC, Ap
3	6	1997 Narrow Row Bean Cooperative Trials	2	UL, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ub, CL, Ca, Cb, HC, P, Ap, Tx	Ub, CL, Ca, Cb, HC
5	4	1999 Manitoba Cooperative Trials	3	UL, Ua, Ub, HC, P, Ap, Tx	UL, Ua, Ub, Ca, P	UL, Ub, HC
2	4	2000 Bean Regional Trials	4	Ua, Ub, Ca, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	Ub
3	4	2000 Manitoba Cooperative Trials	4	UL, Ub, Ca Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	Ca, Cb, HC, P
3	4	2000 Narrow Row Bean Cooperative Trials	4	UL, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	Ua, Ub. Cb, HC, Ap
4	5	2001 Narrow Row Bean Cooperative Trials	5	Ub, Ca, HC	UL, Ua, Ub, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx
5	4	2001 Manitoba Cooperative Trials	5	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Tx	Ua, Ub, Cb, HC, Tx
27	**38**	**Totals**				

1 UL=Hunterlab 'L' colour value, uncooked seed; Ua=Hunterlab 'a' colour value, uncooked seed; Ub=Hunterlab 'b' colour value, uncooked seed; CL=Hunterlab 'L' colour value, cooked seed; Ca=Hunterlab 'a' colour value, cooked seed; Cb=Hunterlab 'b' colour value, cooked seed, HC=hydration coefficient; P=percent washed drained weight; Cl=clumping score; Ap=appearance score; Tx=texture. Variables listed in each column indicate significance ($P<0.05$).

Table 3.4 Number of lines, locations and tests for pink beans evaluated for canning quality.

Lines	Locations	Trial Name	ProgressReport No.	Variety[1]	Location[1]	Variety x Location[1] Interaction
2	6	1997 Narrow Row Bean Cooperative Trials	1	Ua, CL, Cb, HC, P, Cl, Tx	UL, Ua, Ub, CL, Cb, HC, P, Tx	UL, Ua, Ub, Cb, Tx
2	4	1997 Wide Row Cooperative Trials	1	UL, Ua, Ub, Ca, Cb, Tx	UL, Ua, Ub, CL, HC, P	UL, CL, Ca
3	8	1998 Narrow Row Bean Cooperative Trials	2	UL, Ua, Ub, CL, Ca, Cb, HC, Tx	UL, Ua, Ub, CL, HC, P, Tx	Ua, Ub, CL, Ca, Cb, HC, Ap, Tx
2	4	1999 Narrow Row Bean Cooperative Trials	3	UL, Ua, HC, Tx	UL, Ua, Ub, HC, Tx	UL, Tx
3	5	1999 Wide Row Cooperative Trials	3	UL, Ub, Ca, Ap	UL, Ub, HC, P, Ap, Tx	UL, HC, Ap, Tx
3	4	1999 Bean Regional Trials	4	Ua, Ub, Ca, Cb, HC, P, Tx	UL, Ua, Ub, Ca, Cb, HC, Tx	UL, Ca, Tx
3	4	2000 Bean Regional Trials	4	UL, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, Tx	UL, Ub, HC
3	6	2000 Narrow Row Bean Cooperative Trials	4	HC, P, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ap, Tx
4	7	2001 Narrow Row Bean Cooperative Trials	5	UL, Ua, Ub, Ca, Cb, HC, P, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Tx	UL, Ua, Ub, HC, P, Tx
2	3	2001 Manitoba Cooperative Trials	5	Ua, Ub, CL, Ca, Cb, HC, P, Tx	Ua, Ub, Ca, P, Tx	Cb, HC, Tx
27	**51**	**Totals**				

1 UL=Hunterlab 'L' colour value, uncooked seed; Ua=Hunterlab 'a' colour value, uncooked seed; Ub=Hunterlab 'b' colour value, uncooked seed; CL=Hunterlab 'L' colour value, cooked seed; Ca=Hunterlab 'a' colour value, cooked seed; Cb=Hunterlab 'b' colour value, cooked seed, HC=hydration coefficient; P=percent washed drained weight; Cl=clumping score; Ap=appearance score; Tx=texture. Variables listed in each column indicate significance ($P<0.05$).

Table 3.5 Number of lines, locations and tests for pinto bean evaluated for canning quality.

Lines	Locations	Trial Name	Progress Report No.	Variety[1]	Location[1]	Variety x Location[1] Interaction
3	6	1997 Narrow Row Bean Cooperative Trials	1	UL, Ua, Ub, Ca, Cb, HC, P, Cl, Ap	UL, Ua, Ub, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, Ub, Cl, Ap
5	7	1997 Bean Regional Trials	2	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, Ca, Cb, HC, Ap, Tx
2	4	1997 Wide Row Bean Cooperative Trials	2	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P	None
3	8	1998 Narrow Row Bean Cooperative Trials	2	UL, Ua, Ub, CL, Ca, HC, Ap, Tx	UL, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ub,Ca
7	5	1999 Narrow Row Bean Cooperative Trials	3	Ua, Tx	Ua, Ca, Tx	HC
3	4	1999 Wide Row Cooperative Trials	3	Ua, HC, Ap	Ua, Ca, HC, P, Ap, Tx	Ap
5	4	1999 Bean Regional Trials	4	UL, Ua, Ca, HC, Ap	UL, Ua, Ca, Cb, HC, Ap, Tx	UL, Ua, HC
5	5	2000 Bean Regional Trials	4	UL, Ua, Ub, CL, Cb, HC, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, Ap, Tx	Ca, Cb, HC
6	5	2000 Narrow Row Bean Cooperative Trials	4	UL, Ua, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	HC, P, Ap, Tx
2	5	2000 Wide Row Bean Cooperative Trials	4	Ub, Ap	Ua, Ub, CL, HC, Ap, Tx	CL, P
5	6	2001 Narrow Row Cooperative Trials	5	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Tx	Ua, Ca, HC, Tx
4	2	2001 Wide Row Cooperative Trials	5	UL, Ub	UL, Ub, CL, Ca, Cb, HC, Ap	Ub
50	**61**	**Totals**				

1 UL=Hunterlab 'L' colour value, uncooked seed; Ua=Hunterlab 'a' colour value, uncooked seed; Ub=Hunterlab 'b' colour value, uncooked seed; CL=Hunterlab 'L' colour value, cooked seed; Ca=Hunterlab 'a' colour value, cooked seed; Cb=Hunterlab 'b' colour value, cooked seed, HC=hydration coefficient; P=percent washed drained weight; Cl=clumping score; Ap=appearance score; Tx=texture. Variables listed in each column indicate significance ($P<0.05$).

Table 3.6 Number of lines, locations and tests for red bean evaluated for canning quality.

Lines	Locations	Trial Name	Progress Report No.	Variety[1]	Location[1]	Variety x Location[1] Interaction
2	6	1997 Narrow Row Bean Cooperative Trials	2	UL, Ua, Ub, CL, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Cb, HC, P, Ap, Tx	UL, Ua, Ub, Cb, HC
2	4	1997 Wide Row Bean Cooperative Trials	2	Ua, CL, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Cb, HC, P, Tx	UL, Cb
3	8	1998 Narrow Row Bean Cooperative Trials	2	UL, Ua, Ub, HC, P, Ap	UL, Ua, Ub, CL, HC, P, Tx	None
4	4	1998 Wide Row Bean Cooperative Trials	2	UL, Ua, Ub, CL, Ca, HC, P, Ap, Tx	UL, Ua, Ub, HC, Ap, Tx	HC
2	4	1999 Manitoba Cooperative Trials	3	Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, Ub, Ca, Cb, HC, P	UL, Ca
4	5	1999 Narrow Row Bean Cooperative Trials	3	UL, Ua, Ub, CL, Ca, P, Ap, Tx	UL, Ua, Ub, CL, Cb, HC, P, Ap, Tx	UL, Ua, Ub, Tx
3	5	1999 Wide Row Cooperative Trials	3	UL, Ua, Ub, CL, Ca, Cb, HC, Ap, Tx	UL, Ua, CL, Ca, Cb, HC, P, Tx	CL, Ca, Cb, Tx
1	5	2000 Bean Regional Trials	4	N.A.	UL, Ua, Ub, CL, Ca, Cb, HC, Ap, Tx	N.A.
5	6	2000 Narrow Row Bean Cooperative Trials	4	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx
4	6	2001 Narrow Row Bean Cooperative Trials	5	Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	Ub, HC, Tx
5	2	200. Wide Row Bean Cooperative Trials	5	UL, Ua, Ca, Ap, Tx	UL, Ua, HC, Tx	Ca, HC
35	**55**	**Totals**				

1 UL=Hunterlab 'L' colour value, uncooked seed; Ua=Hunterlab 'a' colour value, uncooked seed; Ub=Hunterlab 'b' colour value, uncooked seed; CL=Hunterlab 'L' colour value, cooked seed; Ca=Hunterlab 'a' colour value, cooked seed; Cb=Hunterlab 'b' colour value, cooked seed, HC=hydration coefficient; P=percent washed drained weight; Cl=clumping score; Ap=appearance score; Tx=texture. Variables listed in each column indicate significance ($P<0.05$).

Table 3.7 Number of lines, locations and tests analyzed for canning quality of minor market classes of dry beans.

Bean Type	Locations	Trial Name	ProgressReport No.	Location[1]
Flor de Mayo	6	2000 Narrow Row Bean Cooperative Trials	4	UL, Ua, Ub, CL, Ca, Cb, HC, P, Tx
Golden Pinto Bean	7	2001 Narrow Row Bean Cooperative Trials	5	UL, Ub, HC, P, Tx
Arikara Yellow Bean	6	2001 Wide Row Bean Cooperative Trials	5	UL, Ua, Ub, Ca, Cb, HC, P, Ap, Tx

1 UL=Hunterlab 'L' colour value, uncooked seed; Ua=Hunterlab 'a' colour value, uncooked seed; Ub=Hunterlab 'b' colour value, uncooked seed; CL=Hunterlab 'L' colour value, cooked seed; Ca=Hunterlab 'a' colour value, cooked seed; Cb=Hunterlab 'b' colour value, cooked seed, HC=hydration coefficient; P=percent washed drained weight; Cl=clumping score; Ap=appearance score; Tx=texture. Variables listed in each column indicate significance ($P<0.05$).

Table 3.8 Number of lines, locations and tests for field pea, chickpea and lentil evaluated for canning quality.

Pulse Type	Lines	Locations	Trial Name	Progress Report No.	Variety[1]	Location[1]	Variety x Location[1] Interaction
Field Pea	5	17	1996 Field Pea Regional Variety Trials	1	UL, Ua, Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, CL, Ca, Cb, HC, P, Cl, Ap, Tx
Field Pea	4	13	1997 Field Pea Regional Variety Trials	2	UL, Ua, Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Cl, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC
Chickpea	3	13	1996 and 1997 Chickpea Regional Variety Trials	1	UL, Ua, CL, Ca, Cb, HC, P, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, HC
Chickpea	12	4	1999 Chickpea Regional Variety Trials	4	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap	Ub, Ca, Cb, Tx
Chickpea	10	6	2000 Chickpea Regional Variety Trials	4	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx	UL, Ua, Ub, CL, Ca, Cb, HC, P, Ap, Tx
Lentil (Laird)	2	3	1998 Lentil Cooperative Yield Test	3	None	Ua, Ub, HC, Ap, Tx	CL, Ca
Lentil (Richlea)	2	3	1998 Lentil Cooperative Yield Test	3	UL, Ua, Ub	UL, Ub, Ca, Cb	None

1 UL=Hunterlab 'L' colour value, uncooked seed; Ua=Hunterlab 'a' colour value, uncooked seed; Ub=Hunterlab 'b' colour value, uncooked seed; CL=Hunterlab 'L' colour value, cooked seed; Ca=Hunterlab 'a' colour value, cooked seed; Cb=Hunterlab 'b' colour value, cooked seed, HC=hydration coefficient; P=percent washed drained weight; Cl=clumping score; Ap=appearance score; Tx=texture. Variables listed in each column indicate significance ($P<0.05$).

4. Development of Bleaching Evaluation Techniques for Red and Green Cotyledon Pulse Cultivars

Colour loss (i.e. bleaching) can be a serious problem in green pea wherever it is grown. The extent of the problem differs from year to year, and reflects mainly the degree to which unfavourable weather conditions are experienced at harvest time. Losses of quality due to bleaching can be very severe when late summer weather is cool and damp. Quality losses due to bleaching also occur during shipment of whole green pea to overseas destinations and after splitting or canning.

Previous studies have demonstrated that green pea lines differ in their susceptibility to bleaching. Accordingly, registration of green pea cultivars in Canada requires assessment of their bleaching characteristics (and of green colour intensity, i.e. whether yellow-green or blue-green). The visual assays currently in use, however, are rather crude and qualitative, and require improvement and standardization, and our understanding of the genetics of bleaching resistance is incomplete to say the least. Similarly, our knowledge of the impact of various agronomic and environmental factors on colour retention in green pea is inadequate, as is our understanding of the chemistry and biochemistry of bleaching. It is known that moisture and light accelerate bleaching in green pea, and a number of studies have been conducted on colour retention in green vegetables, for example, but little work has been carried out on low moisture systems like mature green pea.

A method for dehulling both field pea and lentil using a Satake Testing Mill was adapted from Food Science Australia Laboratory Methods (Arganosa et al., 2000). A simple objective method for measuring bleaching was developed for both field pea and lentil (Arganosa et al., 1999, 2000). Bleaching scores for dehulled seed of six red lentil cultivars seeded at eight locations from the 1998 Lentil Cooperative Yield Test, and for

dehulled seed of five red lentil cultivars seeded at three locations from the 1999 Lentil Cooperative Yield Test, were determined using this protocol. Values for the individual varieties and locations can be found in previous progress reports (Arganosa et al., 2000, 2001).

In 1998, the bleaching scores of five red lentil lines, 599-23, 803-18, 837-5, 877-19-R and Crimson, were similar to that of the check cultivar, Redwing. Significant differences among locations and variety x location interactions were observed. In 1999, the bleaching scores of four lines, 599-23, 997-5, 996-30 and 970-19, were similar to that of the check cultivar, Redwing. The bleaching score of 599-23 was significantly greater than that of 966-30 and 970-19. Significant variety x location interactions were observed.

Bleaching scores for dehulled seed of two field pea cultivars, Explorer and Keoma, seeded at thirteen locations in the 1997 Field Pea Regional Variety Trials were also determined using this protocol. Values for the individual varieties and locations can be found in previous progress reports (Arganosa et al., 2000). No significant differences due to variety or significant variety x location interactions were observed. Significant differences in bleaching scores due to location were observed.

4.1 Conclusions

A simple method to measure the bleaching scores of field pea and red lentil was employed to determine if differences existed among lines and locations and to detect variety x location interactions. For red lentil, the bleaching scores of the test varieties

were similar to that of the check cultivar. Significant differences existed among locations, and significant variety x location interactions were observed. For field pea, significant differences among locations only were observed. Much work is required to understand the basis for differences among lines of pea and lentil in their resistance to bleaching in the field and subsequent to splitting. A study on split green pea has been initiated.

5. Development of Nutritional Profiles for Pulse Crops

Established methods for the determination of protein, ash, crude fat, starch and total dietary fibre were used to measure their concentrations in the various market classes of pulses. The list of pulses evaluated is shown in **Table 5.1.** Values for the individual varieties and locations for each trial can be found in previous progress reports (Arganosa et al., 1998, 1999, 2000 and 2001).

A range of values for protein, ash, crude fat, starch and total dietary fibre for each market class was obtained. Significant differences due to location were observed (Arganosa et al., 2001) for pinto bean (protein and crude fat), red bean (protein, crude fat, starch and total dietary fibre) and kabuli chickpea (protein). However, significant differences due to variety as well as variety x location interactions were not observed.

5. 1 Determination of Folate Concentrations in Starchy Grain Legumes

Over the last two decades, the role of folate in human nutrition has been of much interest to health organizations and research professionals because of its possible relationship with several diseases, such as neural tube defects, megaloblastic anemia, chronic disease, malignant transformation and coronary heart disease. Folate is an essential dietary component and is necessary for the formation of red and white blood cells and epithelial cells of the digestive tract. The U. S. Food and Drug Administration has mandated, since 1998, that cereal products should be fortified with 140 µg/100 g of folic acid. Therefore, it is important to establish an accurate database of folate concentrations in cereals and other grains to ensure proper dietary intake of folate.

Folate is a generic term that refers to all derivatives of folic acid, a B-vitamin. Among the many naturally occurring folates, the predominant vitamin derivatives in plants, particularly cereal grains and legume seeds, are polyglutamyl forms of tetrahydrofolic acid (THF), 5-methyl THF and 10-formyl THF. Over the years, various methods of folate determination have been developed, such as a microbiological assay, a radioimmunoassay, an ion exchange chromatography method, a high performance liquid chromatography method and an enzymatic folate-binding protein method. Among them, the microbiological assay has been the most widely used method for folate determination in food. Although the microbiological assay has been modified and improved over the years, the basic concept of the assay has not been changed. *Lactobacillus casei* has been most widely used for determination of folate in food because it responds almost equally to a wide variety of folate derivatives. With the developments in folate analysis methodology in recent years, such as thermal treatment, enzymatic deconjugation and tri-enzymatic digestion, it was necessary to examine the folate content of various foods using the latest methodology. The availability of more precise folate content data for various grains and seeds, pulses in particular in the context of this project, will be beneficial to both food processors and consumers.

In this study, a folate extraction procedure was adapted for the analysis of pulses. Secondly, an existing microbiological assay for folic acid was adapted and modified, and the folate contents of samples of several dry bean, lentil and dry pea (green and yellow) cultivars were determined.

5.1.1 Results and Discussion

A suitable method for the microbiological analysis of folates in pulses was developed. The analytical method (sample extraction and isolation and purification steps) and results were presented in detail in the third and fourth progress reports (Arganosa et al., 2000, 2001). The efficiency, speed and convenience of the microbiological method were greatly improved by employing a series of three enzymes, α-amylase, protease and conjugase, in the sample extraction and purification steps, and using a 96-well microtitre plate and a microplate reader, which made possible the analysis of several samples (3 to 6 samples per plate) simultaneously. The accuracy and reproducibility of the method were verified by analyzing two commercially-available reference samples, human blood and a reference wheat wholemeal flour, and folate-spiked samples. The folate contents determined for the two reference samples, 52.7 μg/100g for wheat wholemeal flour and 381.8 ng/mL for reconstituted human blood, were similar to the folate contents stated by the suppliers, 50 μg/100g and 400 ng/ml, respectively. The percent recovery obtained with samples spiked with commercial folic acid was 96.5% ± 2.3%, indicating a high efficiency of sample extraction, purification and assay.

Two cultivars of each of three dry bean classes grown in three locations, two cultivars of lentil grown in three locations, two cultivars of green pea grown in several locations in two crop years (1999 and 2000), and two cultivars of yellow pea grown in six locations in the 2000 crop year were analysed for their folate contents. All dry bean and lentil samples were from the 1999 crop year. The average folate contents of each dry bean class were determined to be 144.2 μg/100 g for pinto bean, 158.6 μg/100 g for

navy bean and 148.5 µg/100 g for Great Northern bean. No differences in folate content were found between dry bean cultivars of the same market class (**Table 5.2**). The values obtained were generally higher than those reported previously by others (Pederson, 1988; Subar et al., 1989; USDA, 2002). However, due to variations in methodology employed in previous studies, it is difficult to directly compare folate values from this study with those reported by others. Location of growth had a significant effect on the folate content of lentil; cultivar did not (**Table 5.3**). The effect of location on folate content was marked in the case of both green and yellow pea (**Tables 5.4** and **5.5**). Reasons for the effect of environment on folate content were out of the scope of this study and not identified. Further studies on the effect of cultivar and environment on the levels of folate in pulses should be undertaken. No effect of cultivar or crop year on folate content was found for lentil or green or yellow pea.

Folate results were presented as "Analysis of folates in pulses," at the Third Pulse Crop Research Workshop in Winnipeg, MB in November, 2000. A manuscript entitled "Determination of Folate Concentrations in Starchy Grain Legumes (Pulses)" will be submitted to the Journal of Agricultural and Food Chemistry in the near future.

5.1.2 Recommendations

An efficient and rapid microbiological method for analysis of folate in pulses has been developed by incorporating a series of improvements to existing sample extraction and purification steps. The resulting method was accurate and reproducible. The levels of folate in pulses were found to be generally higher than those previously reported,

which may indicate better nutritional quality (with respect to folate content) of pulse crops produced in Saskatchewan or, of course, the effect of method of analysis on the results obtained. The microbiological method can also be used to measure the folate contents of other seed and grain crops. Significant effects of environment and cultivar on the levels of folate in pulses were identified in this study. Further study of these effects would enhance our knowledge of the mechanism of folate synthesis and deposition in pulses and should be undertaken. Routine survey of folate contents of pulse crops grown in Saskatchewan may not be feasible because of the associated cost. However, some systematic analysis of folate content should be performed to confirm the nutritional quality of Saskatchewan-grown pulses and to enhance their marketability.

5.2 References

Pederson, J. C. 1988. Comparison of γ-glutamyl hydrolase (conjugase; *EC* 3.4.22.12) and amylase treatment procedures in the microbiological assay for food folates. *Br. J. Nutr.* 59:261-271.

Subar, A. F., Block, G. and James, L. D. 1989. Folate intake and food sources in the US population. *Am. J. Clin. Nutr.* 50:508-516.

U. S. Department of Agriculture, Agricultural Research Service. 2002. USDA Nutrient Database for Standard Reference, Release 14. Nutrient Data Laboratory Home Page. http://www.nal.usda.gov/fnic/foodcomp (accessed Jan 2002).

Table 5.1 Market classes, including the number of lines, locations and tests, analyzed for composition.

Market Class	Lines	Locations	Test	Progress Report No.
Chickpea	1	7	1996 Chickpea Regional Trials	1
Chickpea	1	7	1997 Chickpea Regional Trials	1
Chickpea	2	4	1999 Chickpea Regional Trials	4
Field Pea	5	9	1996 Regional Variety Trials	1
Field Pea	4	13	1997 Regional Variety Trials	2
Great Northern bean	1	7	1997 Bean Regional Trials	2
Great Northern bean	1	6	1997 Narrow Row Bean Cooperative Trials	2
Great Northern bean	2	7	1998 Narrow Row Bean Cooperative Trials	3
Great Northern bean	2	4	1998 Narrow Row Bean Cooperative Trials	4
Lentil	2	3	1999 Lentil Cooperative Yield Test	4
Navy bean	1	6	1997 Narrow Row Bean Cooperative Trials	2
Pink bean	1	6	1997 Narrow Row Bean Cooperative Trials	2
Pink bean	1	6	1997 Wide Row Bean Cooperative Trials	2
Pink bean	2	8	1998 Narrow Row Bean Cooperative Trials	3
Pink bean	2	5	1998 Narrow Row Bean Cooperative Trials	4
Pinto bean	1	7	1997 Bean Regional Trials	2
Pinto bean	2	6	1997 Narrow Row Bean Cooperative Trials	2
Pinto bean	1	6	1997 Wide Row Bean Cooperative Trials	2
Pinto bean	2	8	1998 Narrow Row Bean Cooperative Trials	3
Pinto bean	2	5	1998 Narrow Row Bean Cooperative Trials	4
Red bean	1	6	1997 Narrow Row Bean Cooperative Trials	2
Red bean	2	5	1998 Narrow Row Bean Cooperative Trials	4
	40	**156**	**Totals**	

Table 5.2 Folate contents of dry bean samples as determined by a microbiological assay[a].

Class	Cultivar	µg/100g	Standard Ddeviation
Pinto	Pinnacle	143.1 a	10.3
	Camino	145.2 a	15.1
Navy	Envoy	156.8 b	11.4
	Laser	160.4 b	13.6
Great Northern	Crocus	152.5 ab	18
	US1140	144.5 a	8

[a] Values are means of quadruplicate determinations. Means with the same letter within the same column are not significantly different (P>0.05).

Table 5.3 Folate contents of lentil samples as determined by a microbiological assay[a].

Cultivar	Location	µg/100g	Standard Deviation
Laird	Saskatoon	165.8 a	7.5
	Rosthern	150.6 b	6.9
	Elrose	194.0 c	8.8
Richlea	Saskatoon	167.3 a	9.1
	Rosthern	150.9 b	5.8
	Elrose	201.2 c	8.5

[a] Values are means of quadruplicate determinations. Means with the same letter within the same column are not significantly different (P>0.05).

Table 5.4 Folate contents of green pea samples as determined by a microbiological assay[a].

Cultivar	Year	Location	µg/100g	Standard Deviation
Nitoche	1999	Kernen	27.4 a	1.8
		Nipawin	35.4 ab	5.9
		Rosthern	24.9 a	4.7
	2000	Kernen	36.1 b	5.5
		Nipawin	30.0 ab	2.7
		Rosthern	25.0 a	3.5
CDC Verdi	1999	Kernen	25.4 ab	2.7
		Nipawin	64.8 c	5.5
		Rosthern	37.8 b	1.9
	2000	Kernen	24.9 ab	2.4
		Nipawin	62.2 c	3.9
		Rosthern	42.2 b	3.3

[a] Values are means of quadruplicate determinations. Means with the same letter within the same column are not significantly different ($P>0.05$).

Table 5.5 Folate contents of yellow pea samples as determined by a microbiological assay[a].

Cultivar	Location	µg/100g	Standard Deviation
CDC Mozart	Assiniboia	46.4 bc	4.3
	Jedbergh	39.5 b	3.8
	Kernen	23.7 a	3.5
	Luseland	55.6 c	3.2
	Nipawin	44.0 b	1.5
	Rosthern	37.9 b	5.6
Alfetta	Assiniboia	46.8 bc	6.1
	Jedbergh	30.2 ab	1.2
	Kernen	26.5 a	2.3
	Luseland	48.7 bc	4.5
	Nipawin	44.3 b	4.8
	Rosthern	33.1 ab	3

[a] Values are means of quadruplicate determinations. Means with the same letter within the same column are not significantly different ($P>0.05$).

6. Spice Quality Evaluation

The list of spices and treatments evaluated between 1996 and 2001 in shown in **Table 6.1.** Values for the individual spices and treatments can be found in previous progress reports (Arganosa et al., 1998, 1999, 2000, 2001).

Methodologies for the determination of essential and fixed oil quantity and quality in spice crops have been established. For coriander, small-seeded varieties contained a higher amount of essential oil and a higher concentration of linalool in the essential oil compared to large-seeded varieties. Differences due to location and variety x location interactions were also observed. Splitting the whole seed prior to seeding, seeding depth, nitrogen and phosphorus fertilization, and seeding rate did not have any significant effect on essential and fixed oil quality and quantity.

For caraway, a range of values for percent essential oil and percent carvone in the essential oil were obtained for four varieties. Seeding rate did not have any significant effect on essential oil quality and quantity.

For anise, the type of priming solution (water or ethanol) and length of priming in water did not have any significant effect on essential oil quality and quantity. Likewise, seeding rate had no significant effect.

For dill, various seeding rate tests were shown to not have any significant effect on essential oil quality and quantity.

Table 6.1 List of spices, treatments and test evaluated between 1996 and 2001.

Spice	Treatment	Test Name	Progress Report No.
Coriander	8 large-seeded and 5 small-seeded varieties	1996 Yield Test 1	1
Coriander	10 large-seeded and 6 small-seeded varieties	1996 Yield Test 2	1
Coriander	8 large-seeded and 5 small-seeded varieties	1997 Yield Test	1
Coriander	6 varieties	1996 Whole Fruit vs Split Fruit Test	1
Coriander	3 seeding depths	1996 Seeding Depth Test	1
Coriander	4 fertilizer levels; 3 varieties	1996 Nitrogen and Phosphorus Fertilizer Test	1
Coriander	50 varieties	1997 Microplots	1
Coriander	4 varieties in 1996; 2 in 1998	1996/1998 Microplots	2
Caraway, biennial	4 varieties	1998 Microplots	2
Anise, caraway, coriander, dill	2 seeding rates	1997/1998 Fall Seeding Study	2
Anise	10 treatments	Anise Priming Study	2
Coriander	11 varieties	1996 Microplots	3
Anise, caraway, coriander, dill	4 seeding rates	1998/1999 Fall Seeding Study	3
Coriander	10 varieties	1999 Yield Test	4
Coriander	10 large-seeded and 10 small-seeded varieties	2000 Coriander	4
Coriander, dill	3 seeding rates	1999/2000 Fall Seeding Study	4
Coriander	10 varieties	2000 Yield Test	4

GENERAL SUMMARY AND CONCLUSIONS

Alternative methods for evaluating the canning quality of dry bean were developed in three phases: i) modified canning protocols using smaller cans; ii) alternative (non-canning) methods; and iii) a near infrared reflectance spectroscopy (NIRS) method. By utilizing modified canning protocols using smaller cans, quality differentiation among different bean lines types was achieved along with a considerable saving of time and resources and a smaller sample requirement. Alternative (non-canning) quality evaluation methods, namely the Mattson cooker method and the quick-cooking method, were developed to avoid the high cost of cans and the requirement for two weeks of storage of canned bean prior to quality testing. The correlation between the alternative methods and the texture of corresponding canned bean was reasonably high; these methods could be used in the early stage of bean breeding when the availability of seed is quite limited and canning data cannot be generated. Finally, an NIRS method was developed as a fast, non-destructive and convenient means of determining the canning quality of bean. Prediction of the texture of canned bean using NIRS looks promising at this point. However, reliable application of NIRS will require calibration from a large pool of representative bean samples, hence further work is necessary and warranted. The potential for using NIRS to evaluate the canning quality of bean is enormous, and it may be that NIRS will eventually replace the canning method for quality evaluation of dry bean.

The canning quality of various types and market classes of pulses (chickpea, dry bean, field pea, lentil) was evaluated. Significant differences in canning quality due to variety and location, in addition to variety x location interactions, were observed.

Significant differences in the composition (protein, ash, fat, starch, total dietary fibre) of pulses due to location were observed. There were no significant differences to due variety and variety x location interactions. A suitable method for the microbiological analysis of folates in pulses was developed. The efficiency, speed and convenience of the method were greatly improved by introducing a series of changes to existing sample preparation steps. The new method was accurate and reproducible.

Methods were developed to measure the essential and fixed oil quality and quantity in various spice crops belonging to the *Umbelliferae* family (anise, caraway, coriander and dill). These methods were used to detect significant differences in essential oil content and composition among the various spices. For coriander, significant differences due to variety, location and variety x location interaction were observed. Other treatments did not have any significant effect on essential and fixed oil quality and quantity. Seeding rate did not have any significant effect on the essential oil quality and quantity in annual caraway, anise and dill. For biennial caraway, a range of values were obtained for essential oil quality and quantity for the four cultivars tested. For anise, type of priming solution and length of priming had no significant effect on essential oil quality.

DISSEMINATION AND USE OF RESULTS

The results obtained from this project have been used by pulse breeders, at the University of Saskatchewan and elsewhere, in making selections based on canning quality. The data were incorporated into annual reports for a variety of cooperative and regional trials, and were used by the Prairie Registration Recommending Committee for Grain - Subcommittee on Special Crops in its evaluation of candidate cultivars. The results have also been incorporated into various other reports, publications and presentations, a list of which is appended to this report.

REPORTS, PUBLICATIONS AND PRESENTATIONS

Arganosa, G.C., Slinkard, A.E. and Sosulski, F.W. 1998. Essential oil content of selected spices in Saskatchewan. Prairie Medicinal and Aromatic Plants Conference, University of Saskatchewan, Saskatoon, Saskatchewan, March 5-7 (oral presentation).

Arganosa, G.C., Vandenberg, A., Nleya, T., Tyler, R.T. and Slinkard, A.E. 1998. Canning quality traits of kabuli chickpea cultivars grown at various locations in Saskatchewan. Soils and Crops '98, Saskatoon, Saskatchewan, February 19-20 (poster presentation).

Arganosa, G.C., Vandenberg, A., Tyler, R.T. and Slinkard, A.E. 1998. Canning quality traits of field pea cultivars grown at various locations in Saskatchewan. Soils and Crops '98, Saskatoon, Saskatchewan, February 19-20 (poster presentation).

Vandenberg, A., Arganosa, G.C. and Slinkard, A.E. 1998. The chickpea crop in 1998. Soils and Crops '98, Saskatoon, Saskatchewan, February 19-20 (oral presentation).

Arganosa, G.C., Slinkard, A.E. and Sosulski, F.W. 1998. Essential oil content of prairie-grown spices. Opportunities and Profits II into the 21st Century Special Crops Conference, Edmonton, Alberta, November 1-3 (oral presentation and proceedings).

Han, J.Y., Tyler, R.T. and Arganosa, G.C. 2000. Analysis of folates in pulses. Third Pulse Crop Research Workshop, Winnipeg, Manitoba, November 19-21 (oral presentation and proceedings).

Han, J.Y., Arganosa, G.C., Tyler, R.T. and Vandenberg, A. 2001. Canning quality of dry beans (*Phaseolus vulgaris* L.). The 86th Annual Meeting of the American

Association of Cereal Chemists (AACC), Charlotte, North Carolina, October 14-18 (poster presentation).

Han, J.Y., Arganosa, G.C., Tyler, R.T. and Vandenberg, A. 2001. Canning quality of dry beans (*Phaseolus vulgaris* L.). Pulse Days 2002 Conference, Saskatoon, Saskatchewan, January 7-8 (poster presentation).

Han, J.Y., Tyler, R.T. and Arganosa, G.C. 2002. Modification of canning protocols for determining quality of dry beans (*Phaseolus vulgaris* L.). Canadian Journal of Plant Science (to be submitted).

Han, J.Y., Tyler, R.T. and Arganosa, G.C. 2002. Determination of folate concentrations in starchy grain legumes (Pulses). Journal of Agricultural and Food Chemistry (to be submitted).

Han, J.Y. and Tyler, R.T. 2002. Determination of the canning quality of dry beans using near infrared reflectance spectroscopy (NIRS). The 87th Annual Meeting of the American Association of Cereal Chemists (AACC). Montreal, Quebec, October 13-17.

ACKNOWLEDGEMENTS

Financial assistance provided by the Canada-Saskatchewan Agri-Food Innovation Fund is gratefully acknowledged. The advice and encouragement of the Saskatchewan Herb and Spice Association and the Saskatchewan Pulse Growers Association are also recognized. The technical assistance of Bonnie Li was greatly appreciated.

STATEMENT OF EXPENDITURES

Statements were provided directly to the Canada-Saskatchewan Agri-Food Innovation Fund by the University of Saskatchewan .

PERSONNEL

Personnel	Time on Project
A.E. Slinkard, Ph.D., Technical Advisor	10%
R.T. Tyler, Ph.D., Technical Advisor	10%
A. Vandenberg, Ph.D., Technical Advisor	10%
G.C. Arganosa, Ph.D., Technical Advisor	33% time
J. Y. Han, Ph.D., Professional Research Associate	60% time
B. Li, Research Technician	100% time